
Friendly Transformer Oils.

Anyone who has been involved in a transformer oil spill or leak knows the headache as well as the expense of cleanup and remediation. Today, most transformers use insulating and cooling fluids derived from petroleum crude oil. Utilities have little choice but to develop extensive contingency plans and detailed procedures that require training personnel and purchasing special equipment to handle accidental spills and leaks of transformer fluid, particularly when contaminated by polychlorinated biphenyl materials. Several recently introduced environmentally friendly fluids could be substituted in transformers and transmission lines, thereby reducing or eliminating these elaborate procedures.

In 1892, General Electric produced the first Transformer using mineral oil as the dielectric coolant. Mineral oils used specifically for power distribution applications were in commercial production early as 1899. Later, halogenated dielectric fluids-principally askarel fluids noted for their excellent fire safety properties-became the fluid of choice for indoor transformers. This is, of course, until the infamous PCB problems of the 1970's. The phase-out of askarels due to their undesirable health hazards and environmental impacts led to a succession of replacement fluids. Silicone oils and high-molecular weight hydrocarbons currently rank as the most popular choices in applications requiring less flammable fluid. To a much lesser extent, synthetic ester-based fluids and synthetic hydrocarbons are also used. Synthetic ester dielectric fluids have suitable dielectric properties and biodegrade much quicker than mineral oil and hydrocarbon fluids. Due to their high cost compared to other less flammable fluids, synthetic fluids are generally limited to use in traction and mobile transformers, and other specialty applications.

Natural ester oils extracted from seed were considered as potential transformer fluids as early as the 1890s. These early ester oils offered no performance or economic benefits over mineral oil. Additionally, seed oil-based coolants' oxidation resistance paled compared to mineral oil, so commercial acceptance did not materialize. However, modern transformers, along with suitable fluid additives and minor design modifications, can compensate for oxidation problems. Used mainly as foodstuffs, these agricultural commodity oils are also a renewable resource, unlike mineral oil-based fluids.

A couple of years ago, Waverly Light and Power, a municipal electric utility in Iowa, had to clean up a 20-gallon spill of transformer oil that was contaminated with PCBs. This spill alone cost the utility more than \$20,000. As he was helping to clean up the mess, Glenn Cannon, Waverly's general manager, thought there had to be a better way.

A solution existed right in Cannon's backyard. Waverly is the heart of soybean-growing country and the home of the University of Northern Iowa's Ag-Based Industrial Lubricants Research Program. The ABIL Research Program studies and promotes soybean-based oils for use in hydraulic and industrial applications. One product of the program is BioSoy, a soybean-based tractor hydraulic oil marketed by AGRI Industries in Des Moines.

Cannon worked with Dr. Lou Honary, the director of the ABIL Research Program, to develop a soybean-based transformer fluid called BioTrans. Since spring 1998, Waverly L&P has been using the oil in five of its transformers and one oil-filled switch. Cannon believes it could be used in transmission lines as well. The fluid is being tested in both retrofill and new transformers. Cannon has filed a patent application for the product with the U.S. Patent and Trade Office. He is also negotiating with NEOS Corp. in California to do more research and eventually manufacture it on a commercial basis.

Right now, BioTrans fluid costs about 25 percent more than traditional fluids, but this could come down with volume production. However, the fluid should be evaluated on a total life-cycle cost basis, which Cannon said could be less for BioTrans fluid than conventional fluids. But maintenance issues still have to be addressed.

Other organizations have recognized the increasing stringency of environmental regulations and liability

risks involving mineral oil-based transformer fluids. Cooper Power Systems began research and development on natural esters in the early 1990s. The result was an edible seed oil-based dielectric coolant called Envirotemp FR3 that is used in the company's new line of Environtran transformers.

Chemically similar, both synthetic and natural ester oils are made by a combination of organic acids and alcohols. The RF3 fluid is a triglyceride consisting of a mixture of saturated and unsaturated fatty acids. A high percentage of the fatty acid consists of the unsaturated type, which results in low viscosity and better low-temperature properties.

Formulated with food grade additives, Envirotemp fluid is non-toxic, even to animals and nonbioaccumulating as well as thoroughly and rapidly biodegradable. Final breakdown products are simply water and carbon dioxide, and the fluid is easily recycled and reused.

Because of its special formulation, Envirotemp is not subject to the federal regulation of used oils and is not listed as a hazardous material by the Environmental Protection Agency and Occupational Safety and Health Administration. Instead, it is covered in the Edible Oil Regulatory Reform Act-making it a much more favorable option when considering environmental risks and regulations. Schools, parks, and ecologically sensitive locations are just some of the locations that can benefit from the new fluid's benign characteristics.

The fluid also had superior fire-resistant properties, including an exceptionally high fire point, enhancing fire safety. Its fire point of 360 degrees Celsius is more than 200 degrees higher than conventional mineral oil and 60 degrees higher than the minimum code requirements for less flammable liquids. Typically, there is no need for a fire vault, automatic sprinklers, special clearances or other additional fire safety requirements.

A biodegradable fluid represents significant potential savings for utilities because it should simplify cleanup and remediation plans and procedures. However, the real savings are realized when a transformer starts to leak or when there is a spill. This is particularly true for utilities in environmentally sensitive areas that have to worry about threats to marine life from spills or leaks from transformers located near the water. The transformers located near the water. The new transformer oil could also represent a large and profitable market for soybean farmers. According to Canon, fluid-filled transmission lines use roughly 7,000 gallons of oil per mile. It is estimated that 4.5 billion gallons of mineral oil are used in U.S. electric systems.